# Results of Investigations on the Possibilities of Reclaiming some Salt Affected Sodic Soils of Yugoslavia

*G. FILIPOVSKI*

*Department of Pedology and Agro-Chemistry, Faculty of Agriculture and Forestry, Skopje, Yugoslavia*

The total area of salt affected soils is about 260,000 hectares in Yugoslavia [3, 9, 10]. Most of these soils are located in Vojvodina [9, 10] and less in Macedonia [1, 2], and the Adriatic coast [3]. A considerable part of these soils belong to the sodic [1, 2, 9, 10] or mixed type of salinization (chloride-sodic, or sulphate-sodic) in which carbonates and bicarbonates predominate. There are numerous data on both field and laboratory investigations of the salt affected soils in Yugoslavia. Nevertheless, we are not finished with laboratory and field tests to investigate the possibilities of reclaiming these salt affected soils.

In this report, the first results of laboratory tests on the effect of gypsum and leaching on the relamation of salt affected sodic salts are given. Profiles of sulphate solonchaks and sodic solonetz, taken from Kocansko Polje in Macedonia, the southern part of Yugoslavia, were studied.

## Methods of laboratory tests

The tests included samples from a profile (No. 128) on sulphate solonchak and from two profiles (No. 107 and 127) of sodic solonetz, which had been cultivated to a shallow depth. The plow layer of 0—20 cm represented a mixture of horizon A and the upper part of horizon B.

Samples from each horizon were placed separately into cylinders to study soil permeability. Thereafter, leaching was performed with five portions of water: first with 250 $cm^3$, then with 500 $cm^3$ and finally three times with 1000 $cm^3$ water. After each leaching the filtrates were sampled and the amount of $CO_3^{2-}$, $HCO_3^-$, $SO_4^{2-}$ and $Cl^-$ was determined. Gypsum was added tothose samples of sodic solonetz, which were impermeable to water.

## Soil properties

In dry years, at the end of summer, ground waters under the sulphate solonchak fall to a depth of 160 cm at most and contain 3.30 g/l of salt in which sulphates and chlorides (about 15 meq./l) predominate. There is less bicarbonate (10 meq./l), while carbonate is nonexistent. In water extracts

of these soils there is 0.77—1.18% salts in different horizons, with the maximum content in the upper part of the profile. There is a predominance of sulphates (14.8 meq./100 g soil) in the surface horizon, with only 1 meq. each of chlorides and bicarbonates. Carbonate is absent. The pH ranges from 8.2—8.7 in various horizons.

In the sodic solonetz the ground waters fall to 130 cm in dry years by the end of summer. They contain 1.04 g/l salts with bicarbonate (10 meq./l) dominating. The amount of sulphates and chlorides is small (a total of 1.4 meq./l). There is very little salt in the water extract of these soils (up to 0.22 g/100 g soil). Bicarbonates are most prevalent, followed by sulphates, and then chlorides. The pH ranges from 9.0—9.2 in individual horizons.

The soils are mainly sandy loam. Only soil 127 (20—40 cm) is clayey.

## Results of laboratory tests

All samples of sulphate solonchak showed very good permeability to water, and the salts leached without any difficulty. There was no tendency for a decrease in permeability during leaching. In contrast to sulphate solonchak, the samples of sodic solonetz were impermeable to water. Only the C horizon sample was permeable to water.

The content of anions in the filtrates after leaching is given in Table 1.

The following may be seen in Table 1 regarding the leaching of salts from sulphate solonchaks:

*a)* The sulphate solonchaks did not decrease in water permeability, and soon lost their salts.

*b)* Most of the readily soluble salts were leached in the first leaching (250 $cm^3$). Salts in the filtrate gradually decreased with subsequent leaching.

*c)* Chloride leached most rapidly. Almost all of the chloride was removed from the soil in the first leaching. The other salts leached more slowly. In filtrates II and III there was a considerable amount of sulphates because of their lower solubility and larger quantity in the soil.

*d)* In all filtrates, the sum of sulphates was greater than the content of sulphates in the water extract (soil: water = 1 : 5). The sulphate solonchaks contain $CaSO_4$, which is only partially dissolved in a given water extract. When soils are leached free of $Na_2SO_4$ gypsum is dissolved in greater quantities. This increases the content of $SO_4$ in the filtrates.

Since horizon C (55—100 cm) of the soda solonetz is permeable to water, the leaching of salts could only take place there. Starting with filtrate III the content of bicarbonate was stabilized at a relatively high level (about 1.70 meq./l). This shows that during leaching, there was a constant formation of bicarbonates through the exchange of the adsorbed Na-ions. Hence, the sum of the bicarbonate content in the filtrates was greater than the bicarbonate content of the water extract of the soil.

The remaining four samples of the sodic solonetz did not transmit water. They were thus mixed with a sufficient amount of gypsum, and then leached. After the addition of gypsum the water permeability rapidly increased and approached that of the sulphate solonchak. Poor permeability was shown only by sample 127 (20—40 cm) with a high content of clay. The results of

*Table 1*

**Content of anions in filtrates obtained by leaching the salts from samples of sulphate solonchaks and horizon C of sodic solonetz**

| Profile No and depth cm | Filtrates | $CO_3^{2-}$ | $HCO_3^-$ | $SO_4^{2-}$ | $Cl^-$ |
|---|---|---|---|---|---|
| | | me./liter | | | |
| *a)* Sulphate solonchak | | | | | |
| 128(0—26) | I | 0.0 | 2.02 | 134.23 | 20.02 |
| | II | 0.0 | 1.03 | 29.49 | 0.25 |
| | III | 0.0 | 0.83 | 6.23 | 0.20 |
| | IV | 0.0 | 0.95 | 0.87 | 0.24 |
| | V | 0.0 | 0.93 | 0.51 | 0.26 |
| 128(26—66) | I | 0.0 | 3.03 | 83.62 | 6.86 |
| | II | 0.0 | 0.99 | 30.10 | 0.23 |
| | III | 0.0 | 0.56 | 9.96 | 0.25 |
| | IV | 0.0 | 0.52 | 3.52 | 0.21 |
| | V | 0.0 | 0.72 | 1.66 | 0.22 |
| 128(81—100) | I | 0.0 | 2.24 | 129.87 | 4.49 |
| | II | 0.0 | 0.70 | 29.69 | 0.32 |
| | III | 0.0 | 0.58 | 25.92 | 0.28 |
| | IV | 0.0 | 0.65 | 2.91 | 0.27 |
| | V | 0.0 | 0.56 | 1.47 | 0.23 |
| *b)* Soda solonetz | | | | | |
| 107(55—100) | I | 0.57 | 5.38 | 1.37 | 0.65 |
| | II | 0.22 | 2.93 | 0.70 | 0.13 |
| | III | 0.20 | 1.70 | 0.51 | 0.11 |
| | IV | 0.26 | 1.71 | 0.78 | 0.10 |
| | V | 0.20 | 1.65 | 0.78 | 0.14 |
| | VI | 0.16 | 1.49 | 0.46 | 0.18 |

*Table 2*

**Content of anions in filtrates obtained by leaching the salts from samples of sodic solonetz after the application of gypsum**

| Profile No and depth, cm | Filtrates | $CO_3^{2-}$ | $HCO_3^-$ | $Cl^-$ |
|---|---|---|---|---|
| | | me./liter | | |
| 107( 0—22) | I | 0.0 | 1.46 | 1.11 |
| | II | 0.0 | 0.32 | 0.72 |
| | III | 0.0 | 0.20 | 0.40 |
| | IV | 0.0 | 0.12 | 0.38 |
| | V | 0.0 | 0.05 | 0.44 |
| 107(22—55) | I | 0.0 | 1.92 | 0.99 |
| | II | 0.0 | 0.28 | 0.63 |
| | III | 0.0 | 0.34 | 0.50 |
| | IV | 0.0 | 0.14 | 0.43 |
| | V | 0.0 | 0.15 | 0.40 |
| 127( 0—20) | I | 0.16 | 2.02 | 0.82 |
| | II | 0.0 | 0.24 | 0.58 |
| | III | 0.0 | 0.16 | 0.43 |
| | IV | 0.0 | 0.10 | 0.38 |
| | V | 0.0 | 0.04 | 0.34 |
| 127(20—40) | I | 0.0 | 0.00 | 6.10 |

*Table 3*

**Reaction of sodic solonetz before and after the application gypsum**

| Profile No and depth, cm | pH before application of gypsum | | pH after application of gypsum | |
|---|---|---|---|---|
| | in $H_2O$ | in KCl | in $H_2O$ | in KCl |
| 127( 0—20) | 8.29 | 7.10 | 7.08 | 6.50 |
| 127(20—40) | 8.80 | 7.29 | 8.25 | 7.22 |
| 107( 0—22) | 9.23 | 8.89 | 7.31 | 6.87 |
| 107(22—55) | 9.21 | 9.05 | 7.34 | 6.87 |

the filtrate analysis after the addition of gypsum to the sodic solonetz are given in Table 2.

The data in Table 2 show the following:

*a)* Soda ($Na_2CO_3$) was wholly neutralized by gypsum and was not present in the filtrates.

*b)* Neutralization of the bicarbonates by gypsum was somewhat slower. They are prevalent in filtrate I only. In the presence of gypsum, there is no tendency of stabilization in the quantity of bicarbonates in the leachates.

Due to changes resulting from the leaching of salts and the addition of gypsum the reaction of the soil changed from alkaline and intensely alkaline to neutrality (Table 3). These results are similar to those obtained in other countries [4, 5, 6, 7, 8] with the same soil types.

## Conclusions

Leaching the salts from some sulphate solonchak soils and adding gypsum and leaching salts from certain sodic solonetz soils of Yugoslavia gave the following results under laboratory conditions:

Sulphate solonchaks were permeable to water and soon lost their salts by leaching. They did not lose their water permeability. Much of the salt was removed in the first leaching. Chlorides leached most readily, while sulphates and bicarbonates leached more slowly. The sum of the sulphate content in the filtrates was greater than the sulphate content of a water extract, because of the content of gypsum in the sulphate solonchaks. Leaching caused a "self-reclamation" of these solonchaks because the gypsum calcium from the soil exchanged the adsorbed Na-ions. A neutral reaction was obtained.

The sodic solonetz soils were not water permeable, except for horizon C. Leaching this horizon caused the content of bicarbonates to stabilize in the filtrate at a relatively high level, because they formed in the soil through the exchange of adsorbed Na-ions. Samples of the other horizons became permeable with the addition of gypsum. Leaching and the application of gypsum caused the carbonates to disappear sooner than the bicarbonates. The composition of the salts changed. The adsorbed Na-ions were exchanged, and the soil became neutral.

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